Airborne measurements of the vertical distribution of several trace gases during the POLARCAT spring 2008 campaign

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SAFIRE

1.Context

Fig 1. Flight tracks during the POLARCAT-CNRS campaign in Kiruna

In the framework of the International Polar Year, the POLARCAT project executes a series of aircraft experiments to follow pollution plumes transported into the Arctic. These experiments take advantage of the long residence times of pollutants in the stably stratified Arctic atmosphere, which serves as a natural laboratory for investigating processes that cannot be studied elsewhere in such isolation.

The CNRS-spring campaign took place in Kiruna, Sweden, between March the 27th and April the 14th of 2008. It was dedicated to microphysics and satellite validation. The ATR-42 from SAFIRE performed 12 flights above the Arctic from Kiruna and Enna airport.

2. Scientific objective

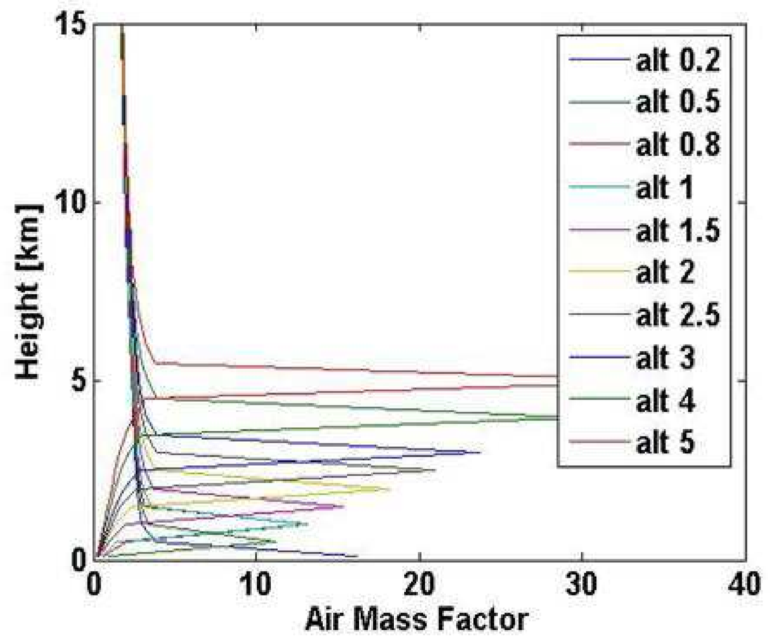

Fig 3. Air mass factor simulations for BrO at 352 nm in the limb geometry

BIRA-IASB participated to this campaign with a new instrument, namely the Airborne Limb Scattering Differential Optical Absorption Spectrometer (ALS-DOAS). Our objective is to retrieve vertical distributions of several trace gases playing a key-role in the troposphere, NO_2, O3, H2CO and BrO.

Simulations with a radiative transfer model, UV-SPEC/DISORT were performed for both BrO an NO_2 . They show that limb geometry is well suited to retrieve profile of small absorbers like BrO thanks to large air mass factors

3. The Airborne Limb Scattering DOAS (ALS-DOAS)

- Wavelength range : 332-450 nm
- Spectral resolution: 0.4 to 0.6 nm
- Field of View : 1.2 °
- Telescope scanning from +5 to -5° around the horizontal of the plane
- Optical fiber bundle-slit to minimize telescope lens size
- Custom-made passive thermal insulation

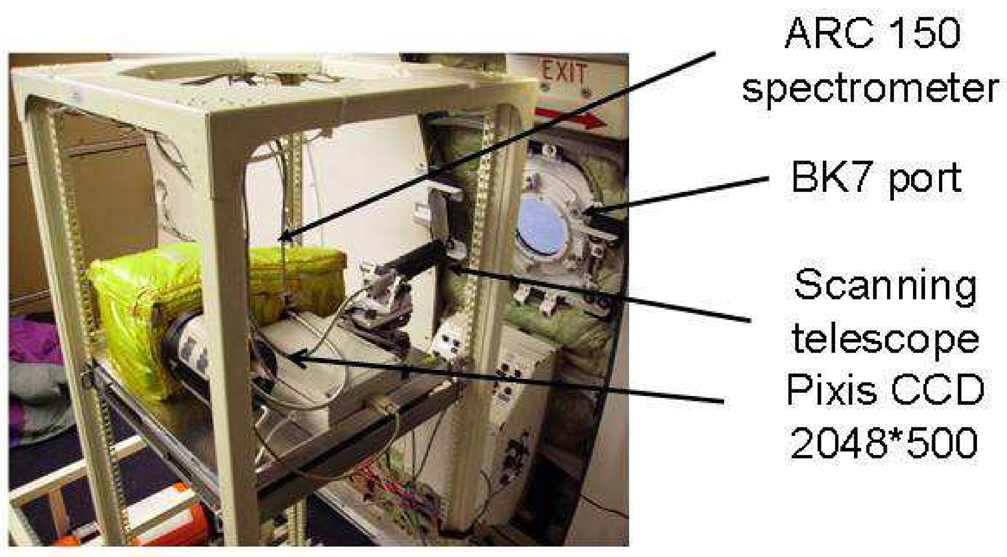

Fig 4. The ALS-DOAS onboard the ATR-42

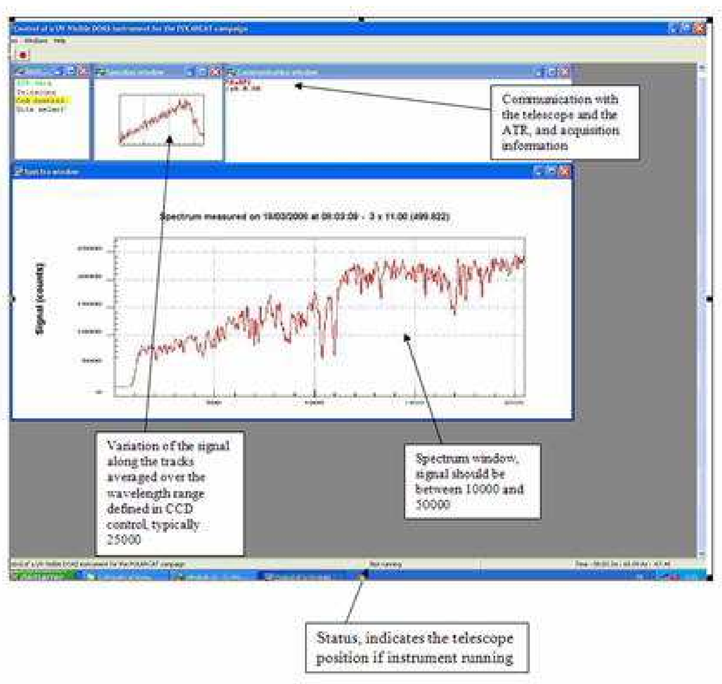

Fig 5. The acquisition software interface

The acquisition software controls the telescope and the CCD, calculating the integration time and saving the spectra.

The program runs automatically once started. An operator is practically not needed during the flight for the ALS-DOAS

4. Preliminary results

The major steps of the data processing are the following:

1. Correction for the spectral stray light in our measurements
2. Georeferencing of the spectra with the plane position, attitude and cap data
3. Retrieval of the slant columns of the different species compared to a reference spectra (DOAS method)

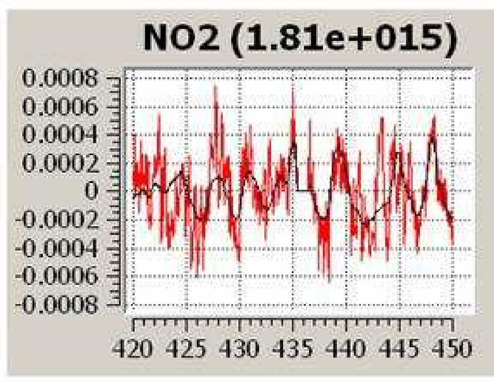

Fig 7. DOAS fit of the NO2 column with QDOAS

4. Determining the residual columns in the reference spectra
5. Profile inversion with the Optimal Estimation method, based on the know-how acquired at BIRA-IASB with ground-based MAX-DOAS measurements. The forward model is based on LIDORT.

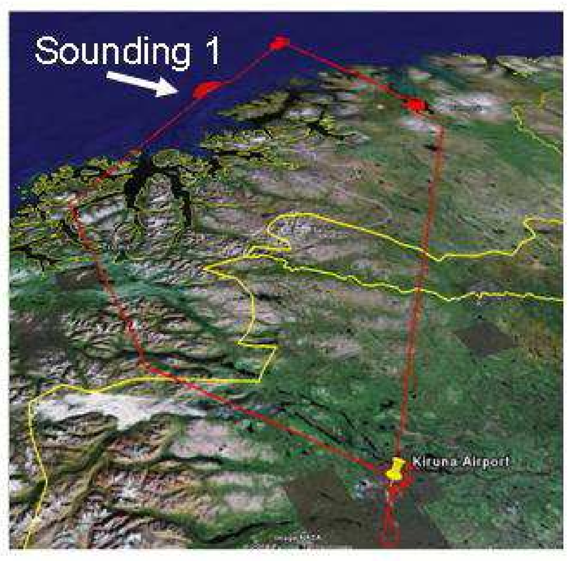

Fig 6. AS0831 and AS0832 flight trajectory

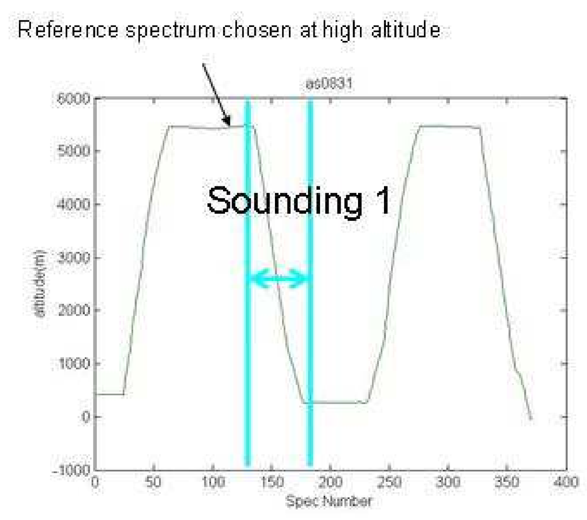

Fig 6. Georeferencing the data: spectra number versus altitude

We are now working on retrieving the slant columns for the different sounding achieved during the flights

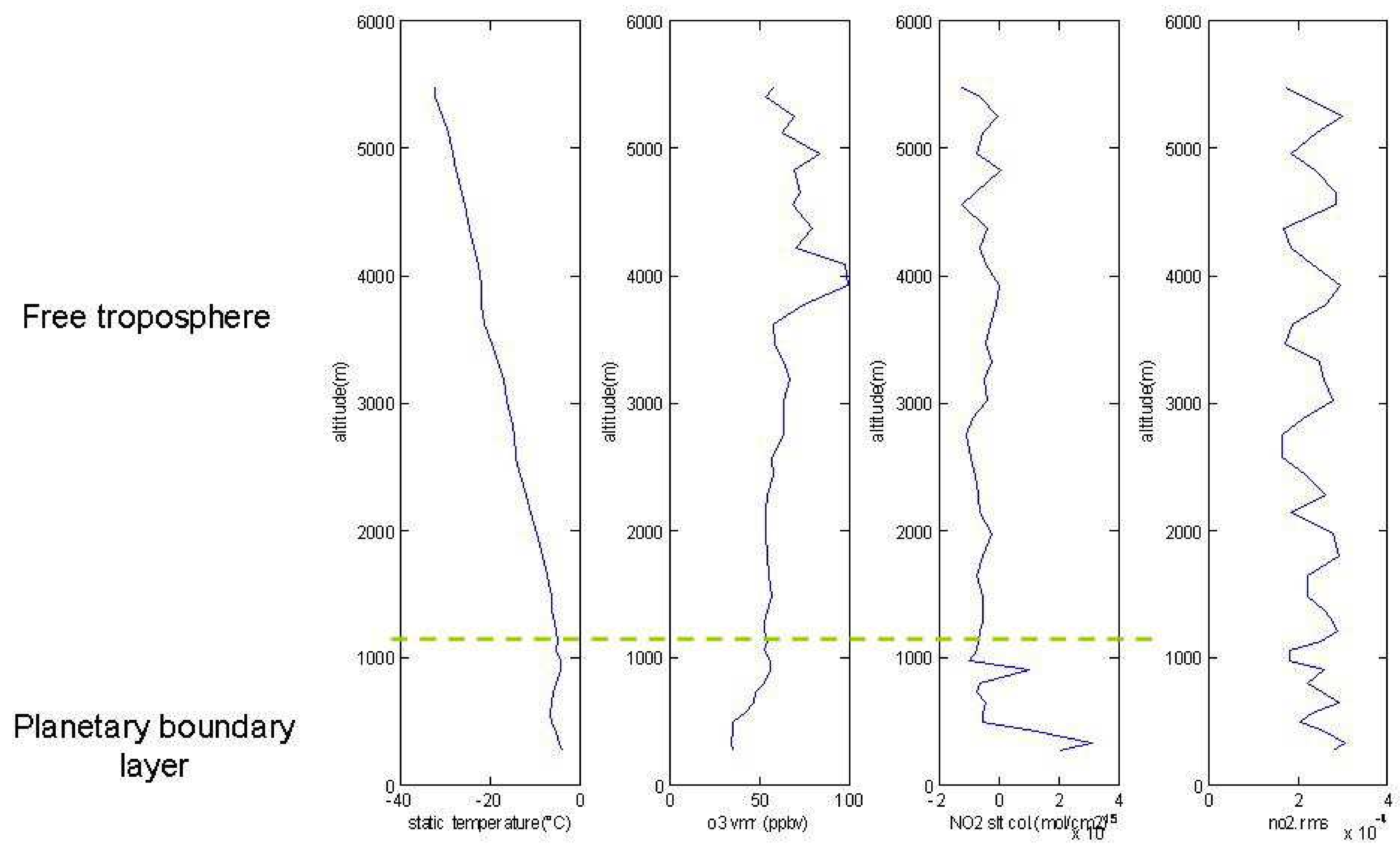

Fig 8. AS0831 Sounding 1, Temperature and Ozone VMR are from the aircraft in-situ instrumentation, the NO2 slant columns are from our ALS-DOAS. The right-end plot shows the DOAS fit residuals

5. Future work

1. Optimize stray light correction (Zong method)
2. Optimize DOAS analysis settings for the different molecules
3. Development if the profiling algorithm based on the Optimal Estimation Method
4. Validation

Aknowledgements

We thank EUFAR for funding our participation to the campaign. We thank also the organizers of the Kiruna spring CNRS campaign to have enabled us to take part in this experiment